

# A Look at Energy Distribution of QE Events in the Antineutrino Data

- goal: show how well energy distribution agrees in data, MC for possible inclusion in PAC talk (Mar 29th)?
  - important to show that we can simulate our  $\bar{\nu}$  data given 25m absorber issues
- QE is best sample for this (high statistics, can reconstruct  $E_{\nu}^{\text{QE}}$ )
- use neutrino mode QE selection and apply to antineutrino mode data ...

# Antineutrino Mode QE Selection

- use exact same QE selection as in neutrino mode:

- event within beam spill (4400-6400 ns)
- $V_{\text{hits}}(1) < 6$ ,  $V_{\text{hits}}(2) < 6$
- $T_{\text{hits}}(2) > 200$ ,  $T_{\text{hits}}(2) < 200$
- radius  $< 500$  cm

standard  
“pre-cuts”

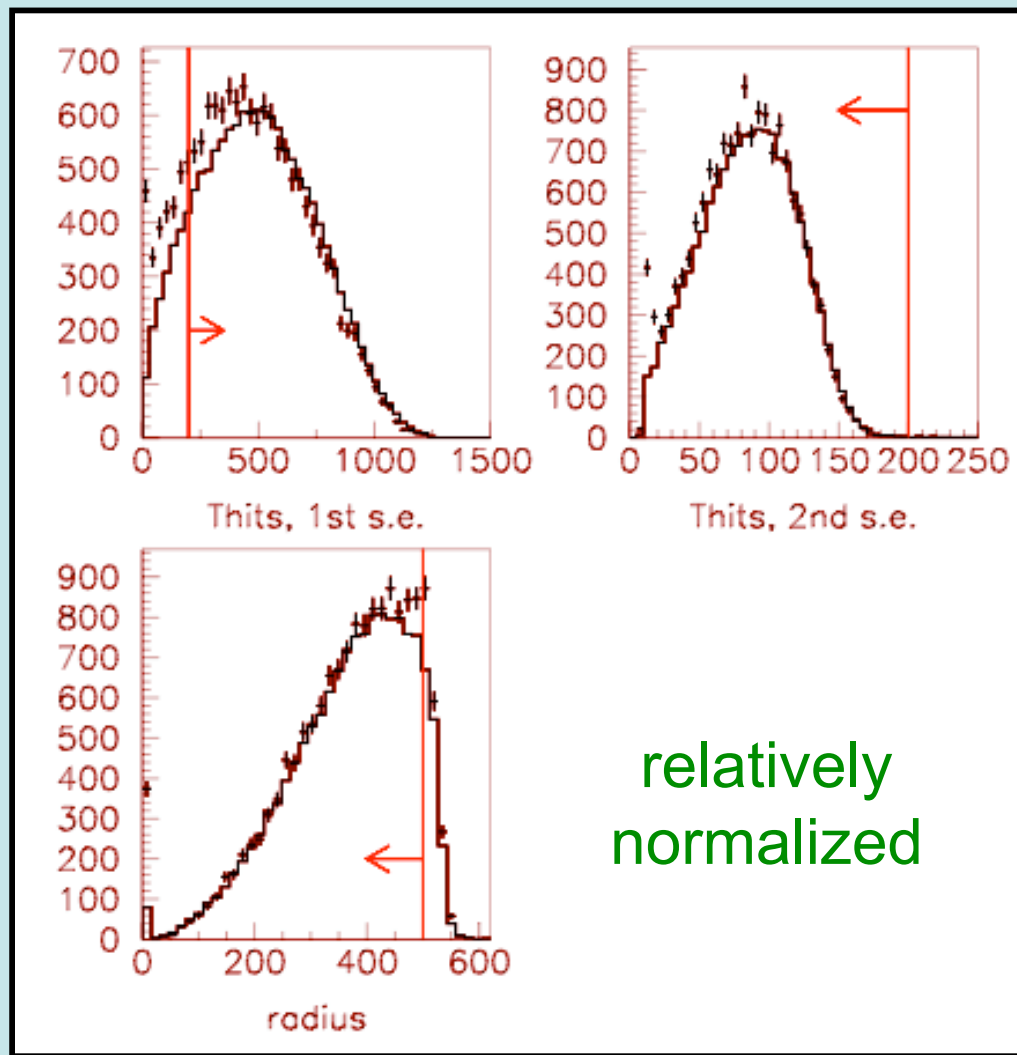
- 2 and only 2 subevents (CC event)
- Michel distance  $< 100$  cm (Michel assoc w/  $\mu$ )

Stancu-based  
QE selection

- if had been applying Fisher cut, then might have argued that same cuts should not apply (but using simpler selection)

- neutrino mode:  $\nu_{\mu} n \rightarrow \mu^{-} p$
- antineutrino mode:  $\bar{\nu}_{\mu} p \rightarrow \mu^{+} n$

# Some of Variables Cut On



(more on this later)

# Number of Events

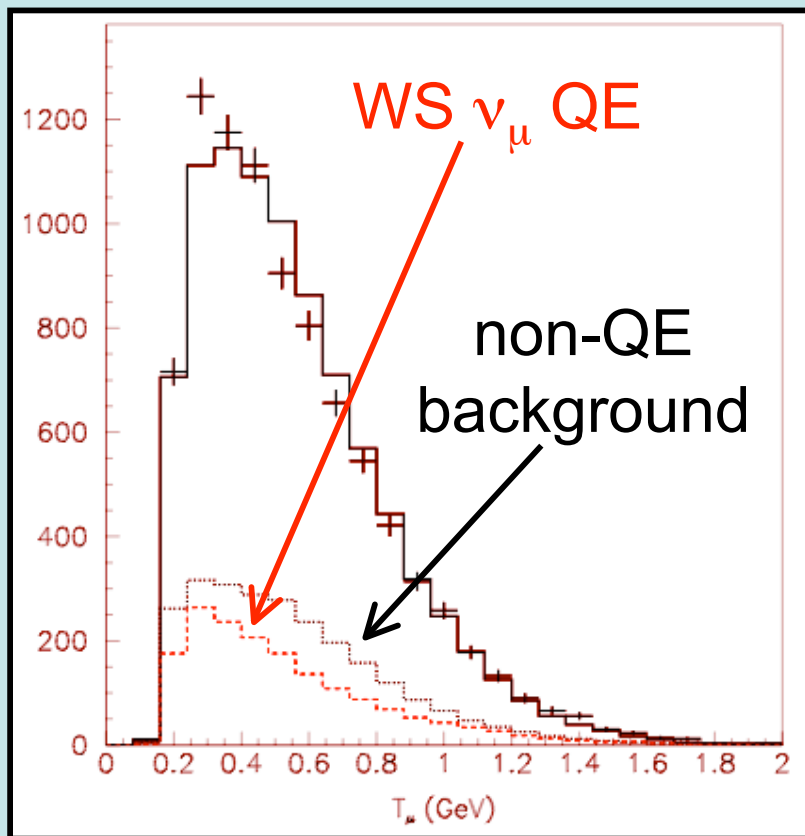
- **8772** events pass QE selection in antineutrino mode  
(have run over all of the data,  $1.5 \times 10^{20}$  POT)
  - $\left\{ \begin{array}{l} - 12\% \text{ of data taken with no absorber plates in beam} \\ - 45\% \text{ of data with absorber plate \#10 in beam} \\ - 43\% \text{ of data with both absorber plates in beam} \end{array} \right\}$
- so, 88% of total QE nubar data had some beam obstruction

# Event Composition

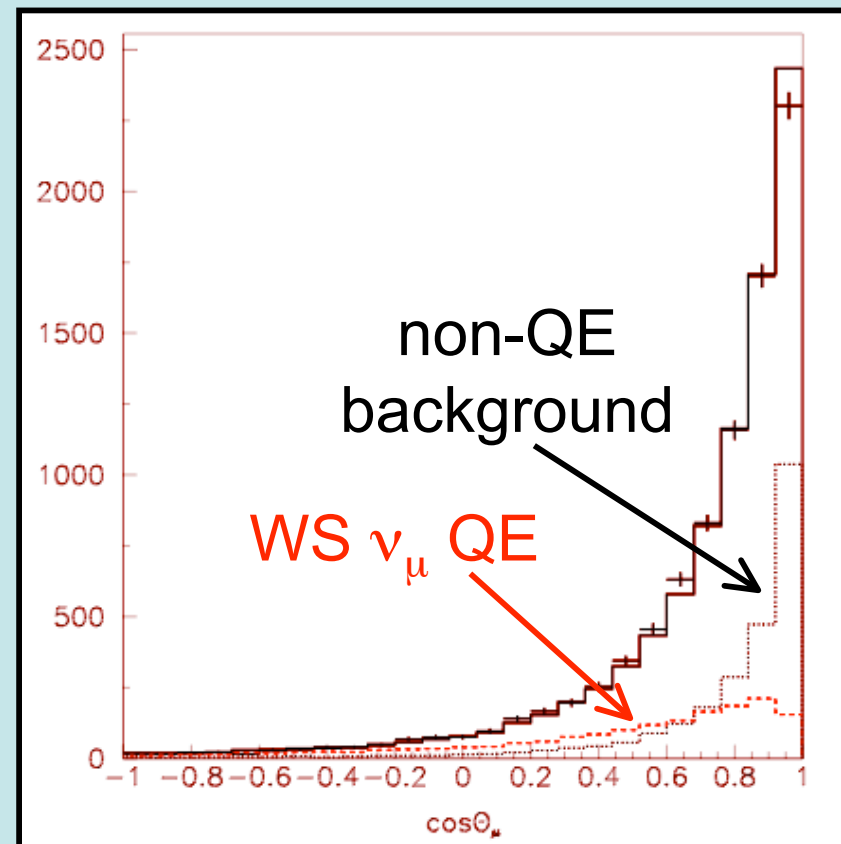
- 27% of events are predicted to be WS  $\nu_\mu$  & 73% are RS  $\bar{\nu}_\mu$
- according to the Monte Carlo, this sample is:
  - 53%  $\bar{\nu}_\mu$  QE
  - 19%  $\nu_\mu$  QE
  - 15%  $\bar{\nu}_\mu$  CC  $\pi^-$
  - 5%  $\nu_\mu$  CC  $\pi^+$
  - 3%  $\bar{\nu}_\mu$  QE hyperon production ( $\Lambda$ ,  $\Sigma^-$ ,  $\Sigma^0$ )
  - 3%  $\nu_\mu$  and  $\bar{\nu}_\mu$  CC  $\pi^0$
  - 2% other

# Kinematic Comparisons

- relative norm, MC without 25m absorber plates simulated



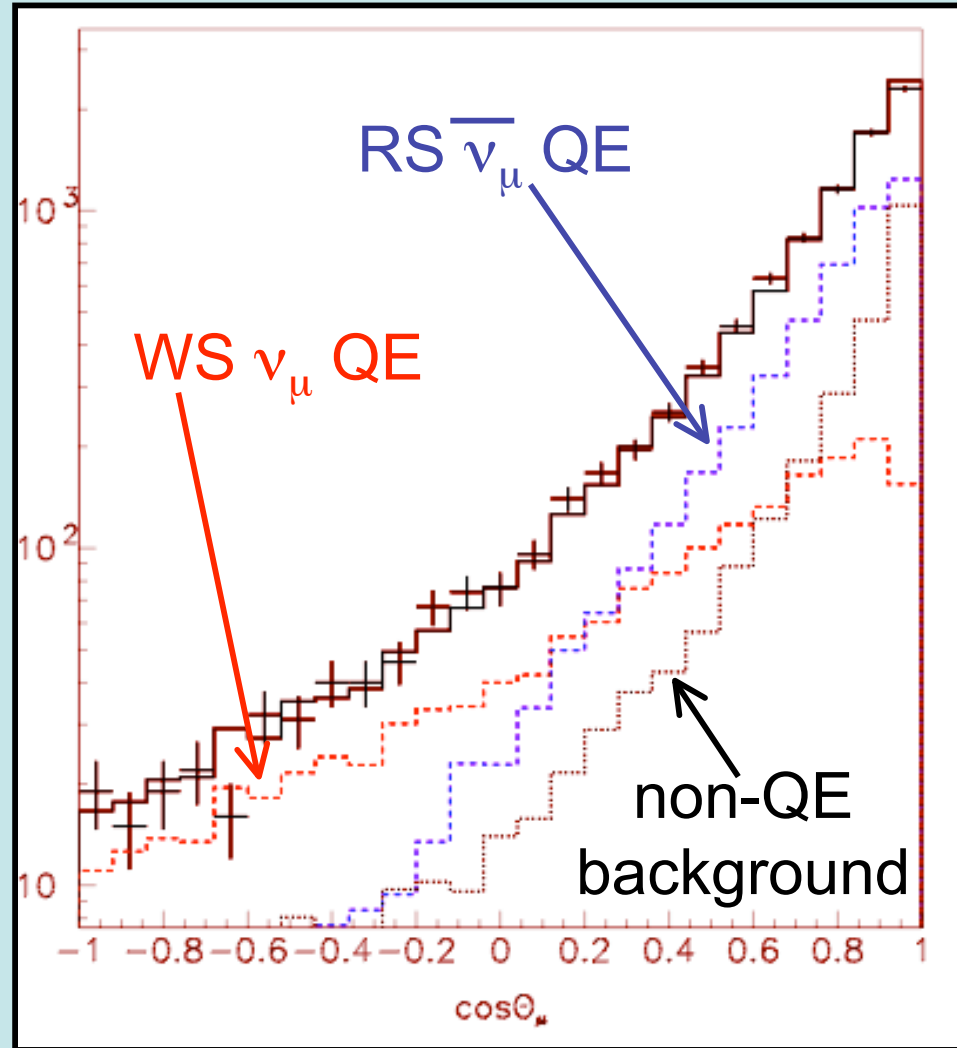
muon kinetic energy



muon scattering angle

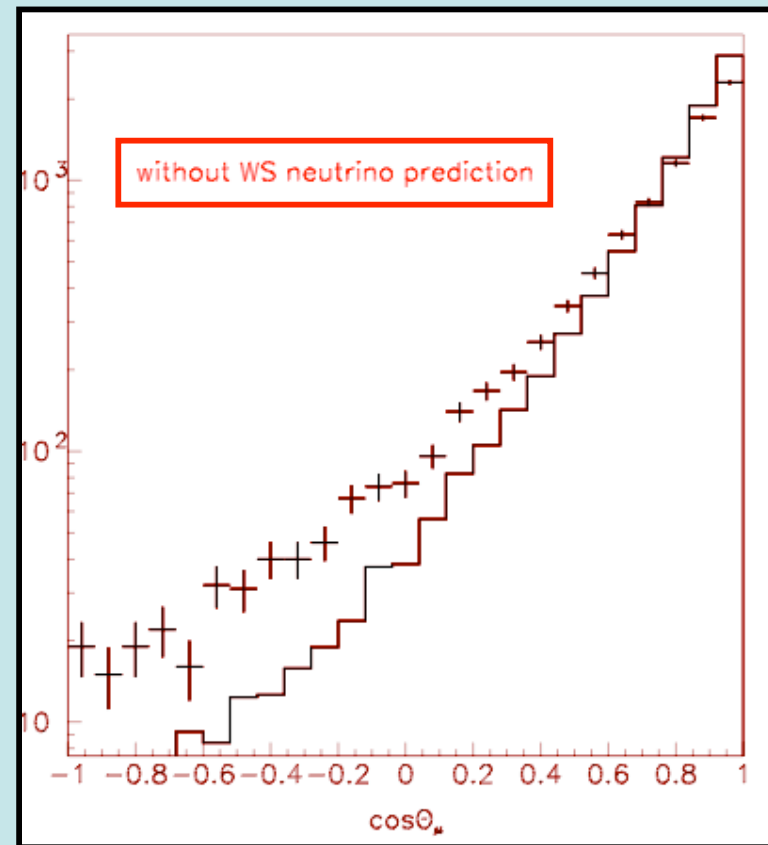
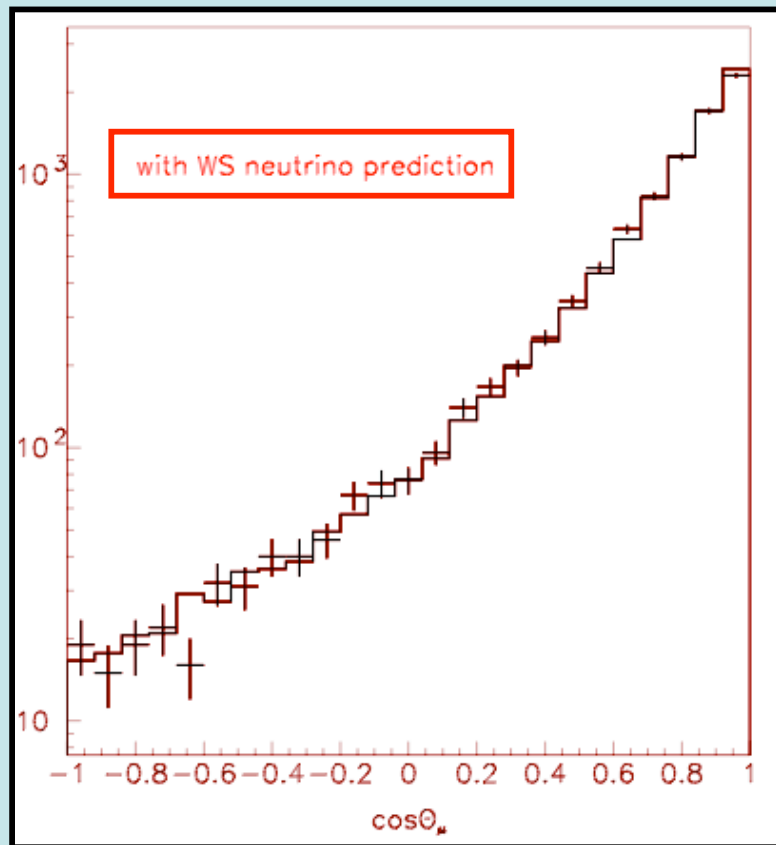
# Muon Angular Distribution

- this is the distribution that can tell us about WS content in the beam
- plot shows our default MC predictions (27% WS)
- current WS prediction does not seem far off (consistent w/ Adish/Heather's findings last summer; they can repeat their fits to get exact #'s)



# Muon Angular Distribution

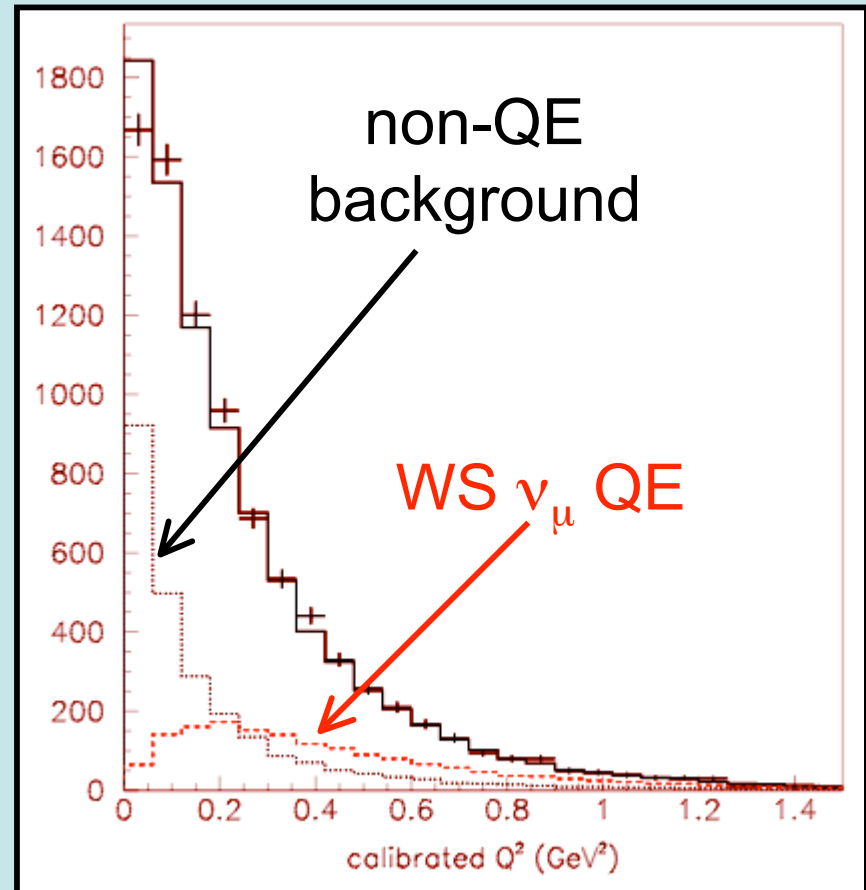
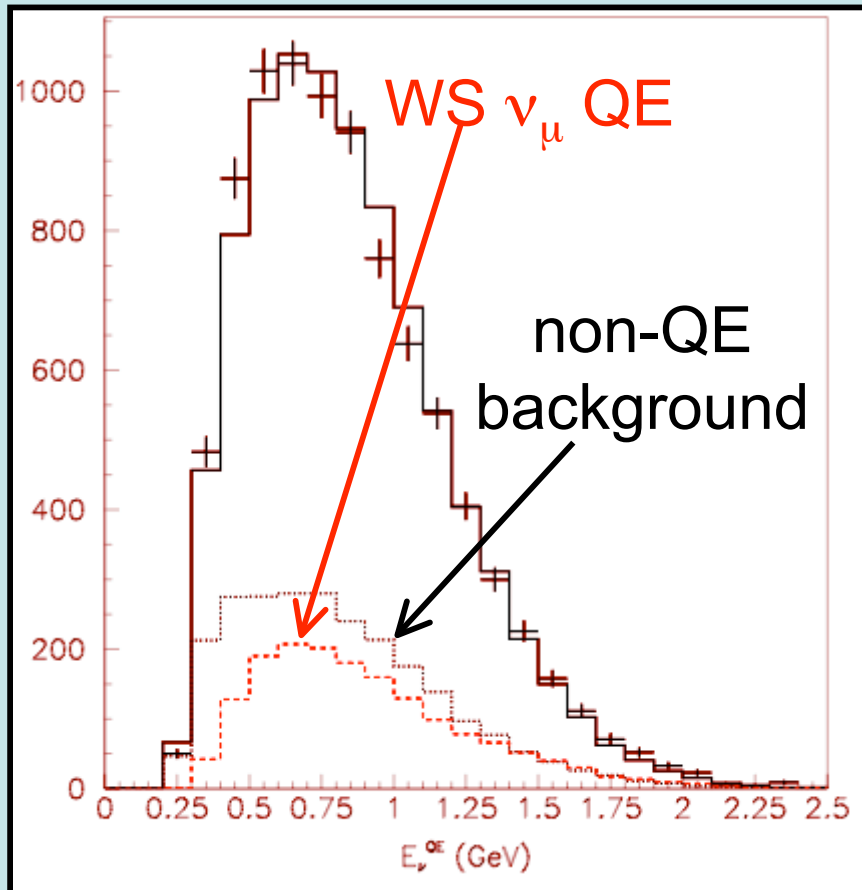
- can get some sense of our sensitivity to WS content
- both relatively normalized to the data ( $1.5 \times 10^{20}$  POT)





# Kinematic Comparisons

- relative norm, MC without 25m absorber plates simulated

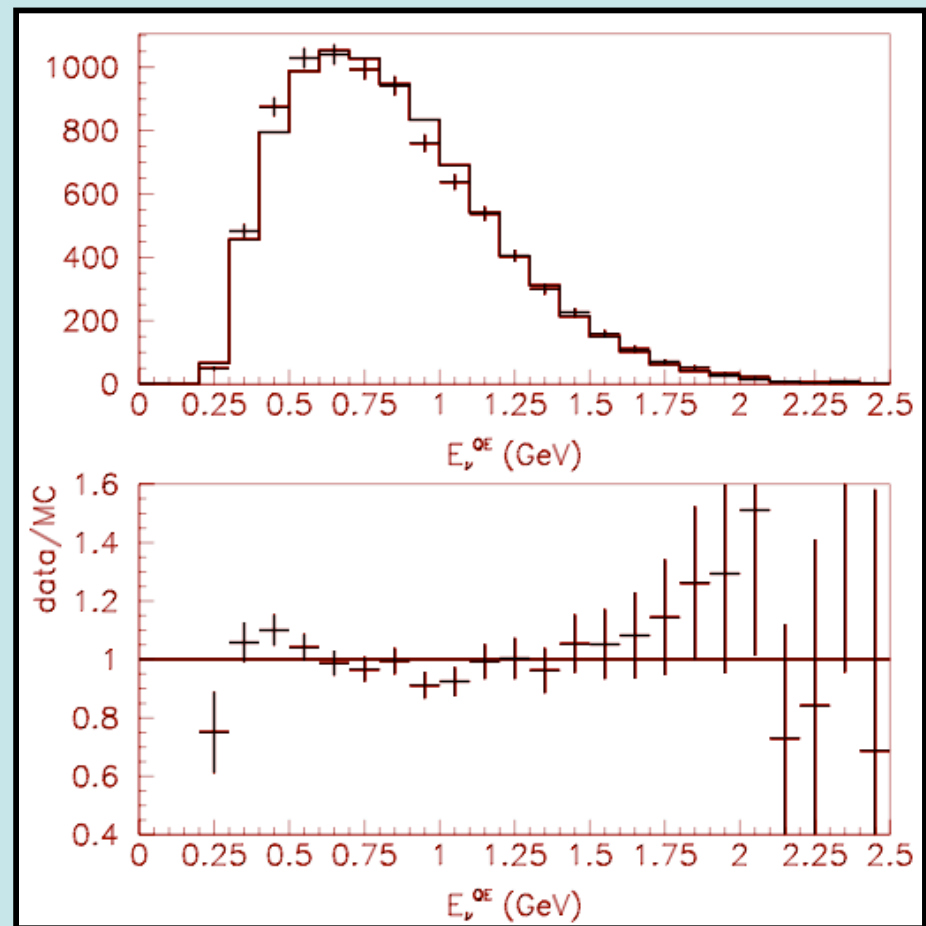


(with neutrino mode QE model pars) 9

# Neutrino Energy Distribution

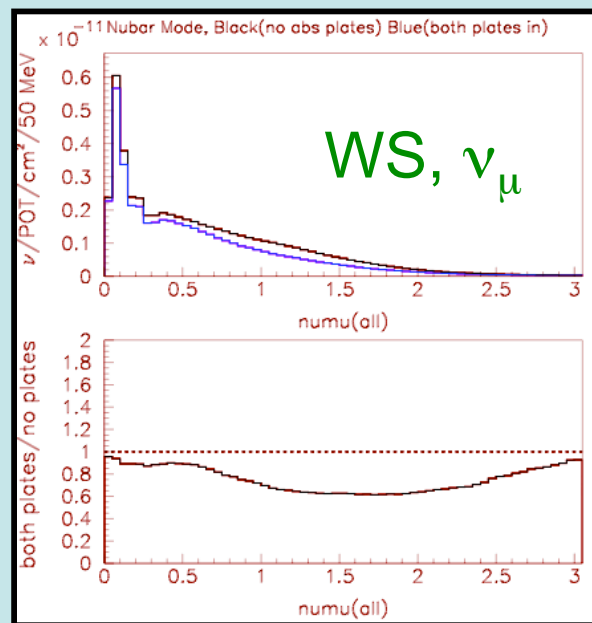
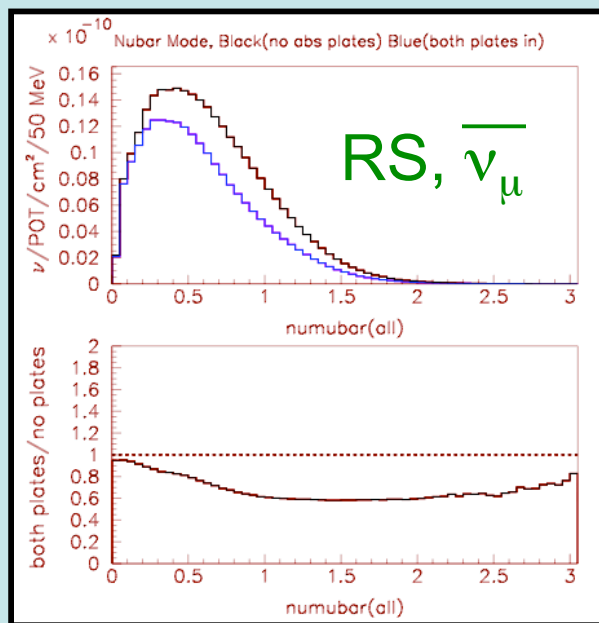
- relative norm, MC without 25m absorber plates simulated

- this is type of distribution could show at PAC
- $E_\nu$  spectrum agreement pretty good despite not having plates simulated
- but we can do better ...



# As a Test - Reweight Effect of Absorber

- Geoff is generating new MC samples, but in meantime ...
- reweight  $\bar{\nu}_\mu$ ,  $\nu_\mu$  generated  $E_\nu$  according to Wilking's flux ratios

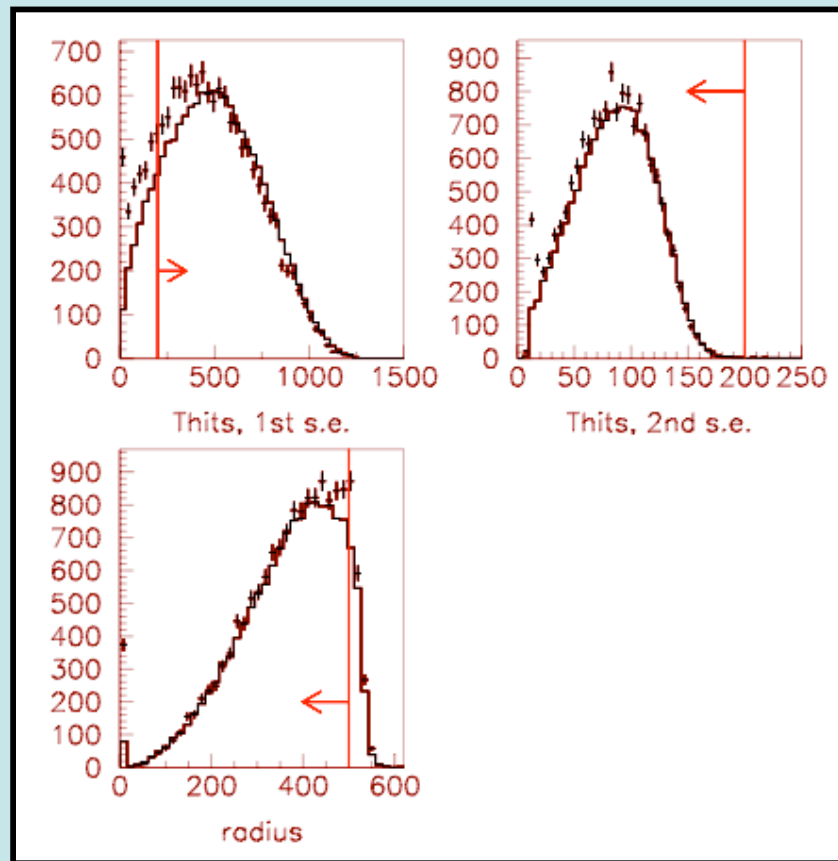


(example:  
both plates in)

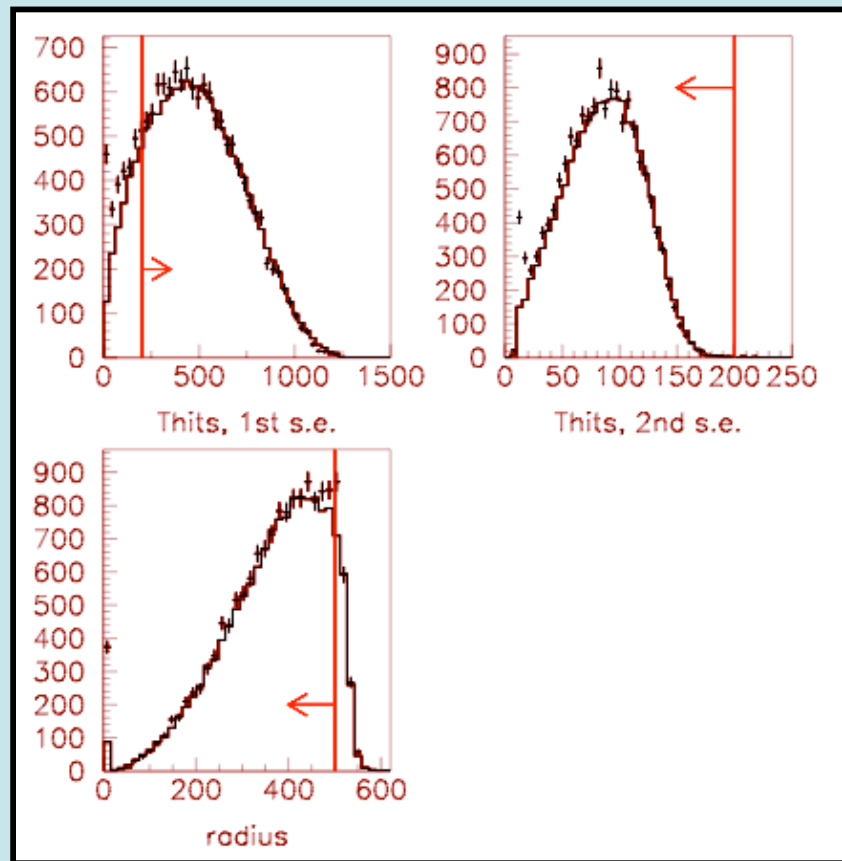
- reweight 45% of events with plate 10 in beam
- reweight 43% of events with both plates in beam

# Estimating Effect of Absorber Plates

MC with no absorber plates:

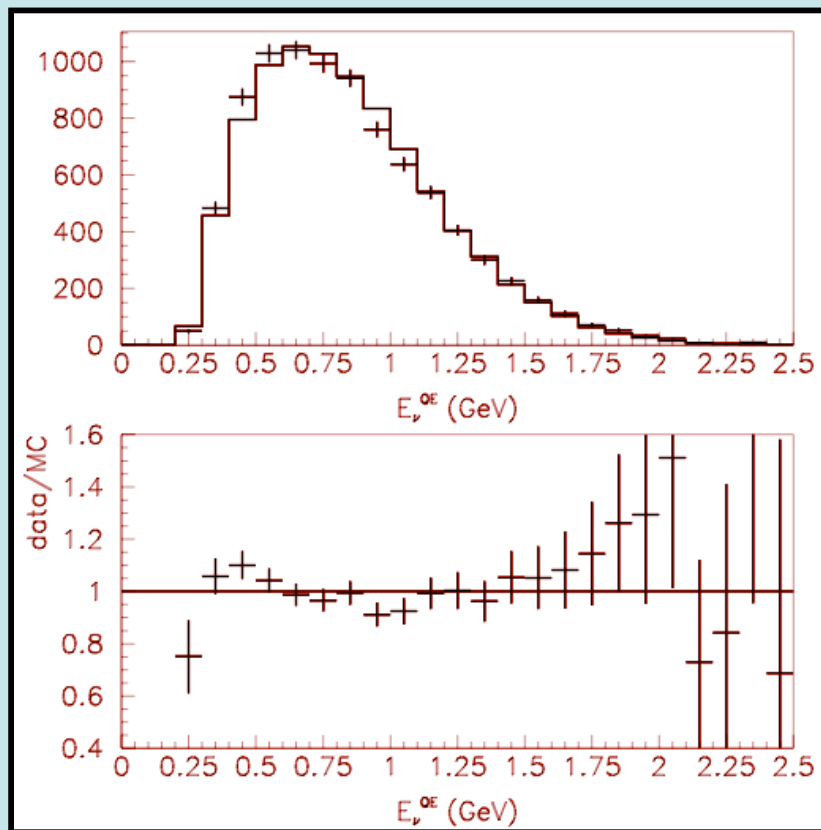


MC reweighted according to fraction of events with one & both plates in beam:

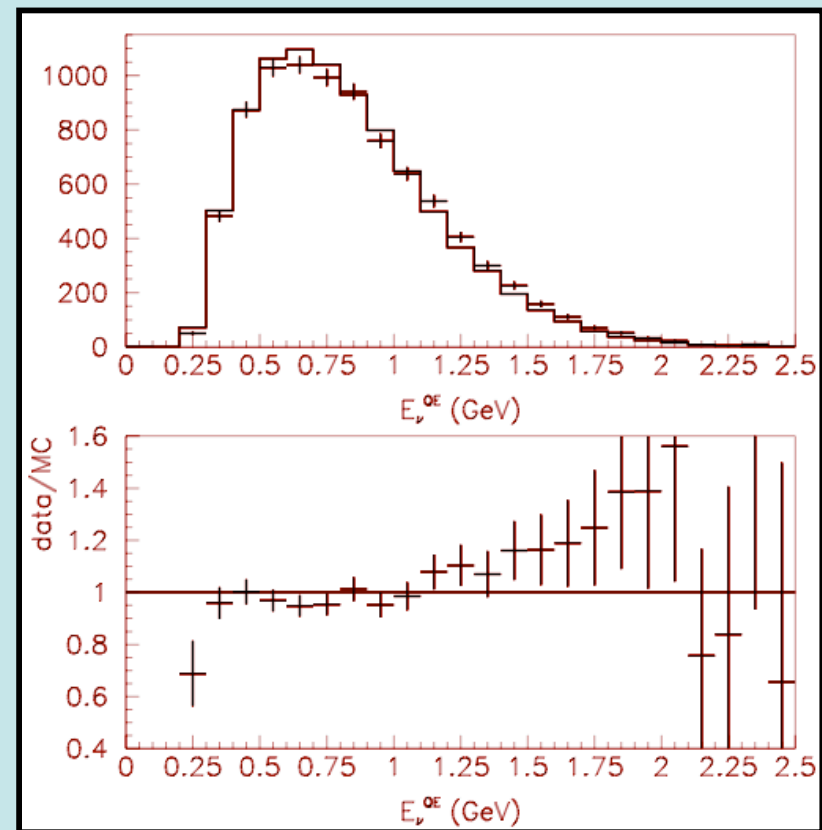


# Estimating Effect of Absorber Plates

MC with no absorber plates:



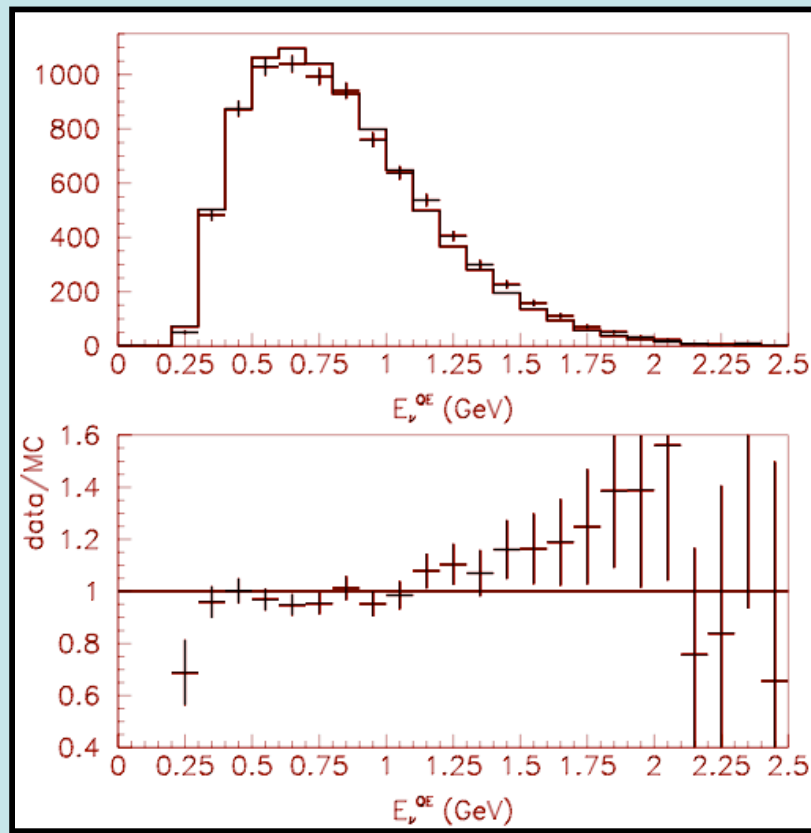
MC reweighted according to fraction of events with one & both plates in beam:



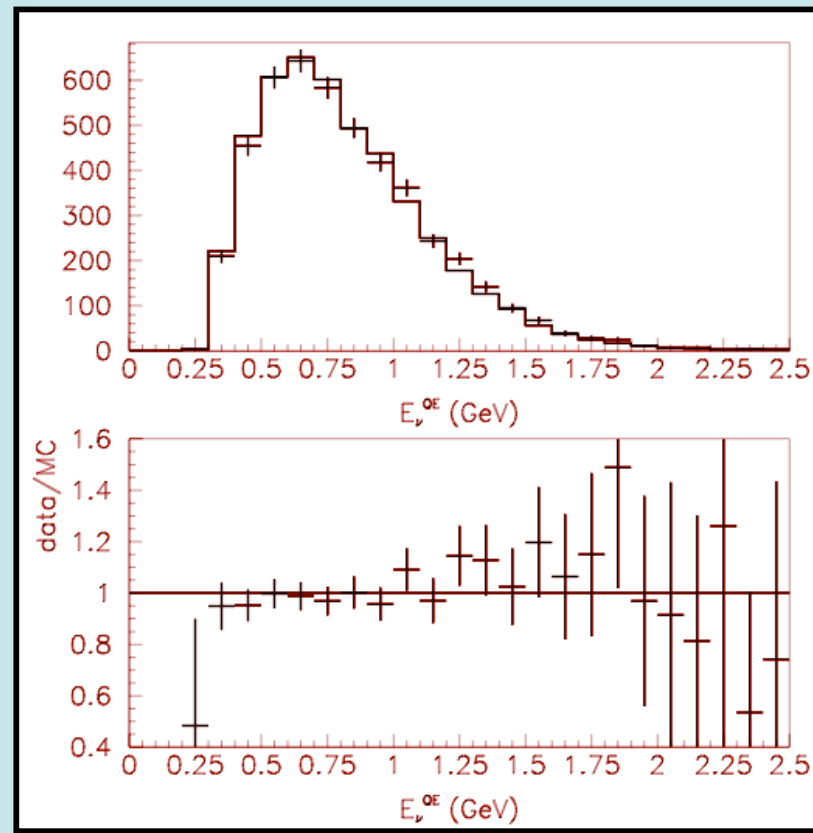
- shows new flux should improve things, new MC will be real test (Geoff)

# With Absorber Plate Reweighting

- Stancu-based QEs  
(same as RH plot on page 13)



- Reconstruction QEs  
(using 1-t P-fitter)



# Conclusions

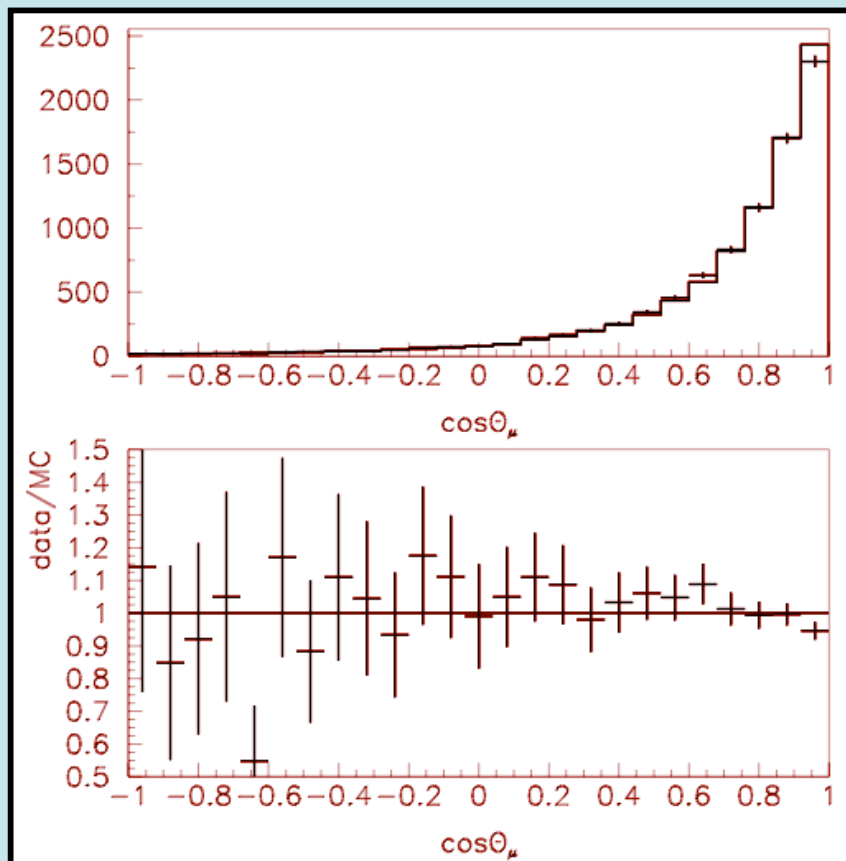
- data, MC agreement in antineutrino QE sample looks pretty good (based on 8k events,  $1.5 \times 10^{20}$  POT)
- our wrong-sign predictions are not far off
- indications are that new Monte Carlo with plates simulated should further improve data, MC agreement

# Backups

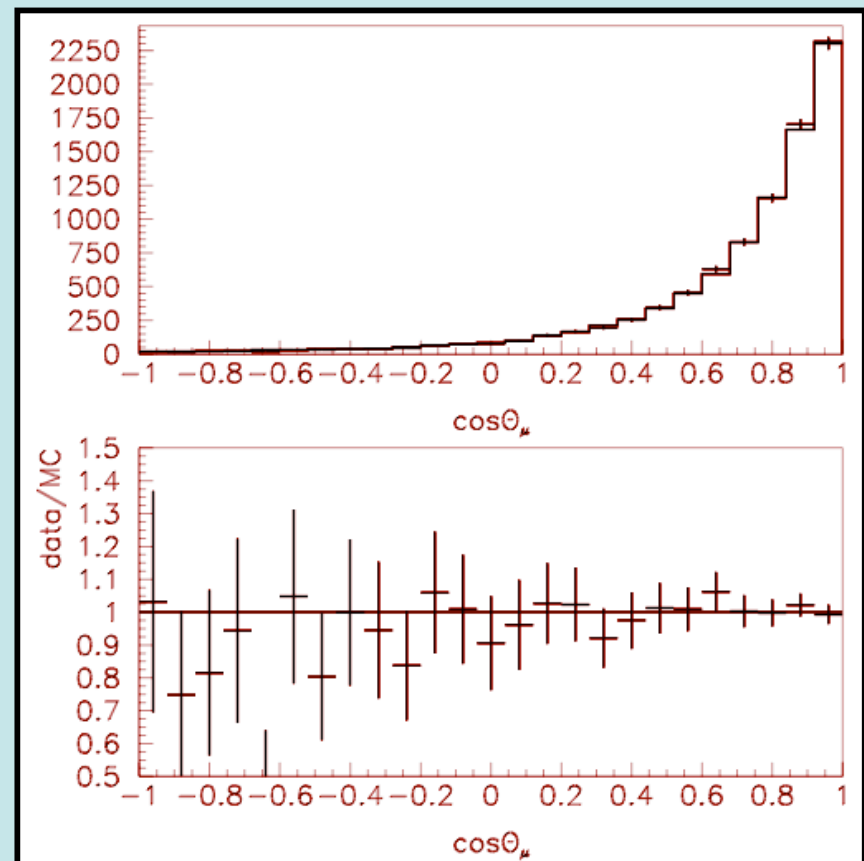


# Estimating Effect of Absorber Plates

MC with no absorber plates:



MC reweighted according to fraction of events with one & both plates in beam:



# QE Model

- however, do not recommend showing such high level plots at PAC presentation (too premature)

